

Application of PI controller based active filter for harmonic mitigation of grid-connected PV-system

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ABSTRACT

The recent trends show the interconnection of PV system with electric grid. With this configuration the issue of harmonics comes into existence. The mounting figure of power-electronic instruments has formed considerable impression on the power-quality of electric supply. Harmonics deformations have conventionally been handled amid the application of passive-LC filters. Active Filter has emerged as a good substitute for passive filters to reduce the harmonics to great extent as it has numerous benefits over the former filters. The active filter's most vital part is the applied control strategies. Several researches are being under process to advance the functioning of the filter. One of the important control requirements of filter is the regulation of DC link up capacitor voltage. Here the voltage supervision of capacitor is being done using PI controller. The paper show current harmonics compensation of PV grid connected system using PI controller based active filter. Simulation outcomes have been shown which displays the harmonics are within the IEEE boundaries.

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1. INTRODUCTION

Harmonics have been, in modern era, a significant and rising problem due to propagation in use of various power electronic (PE) devices in typical power distribution systems [1]-[4]. While integrating PV system to grid also causes use of PE converters resulting in an increase in harmonics. Mostly, voltage harmonics problem results from the current harmonics. These harmonics can disturb the supply voltage and the whole grid configuration [5]-[7]. It is renowned that harmonic current give rise to various problems in the electric power supply, for instance: low pf, low down of energy efficiency, EMI issues, deformation of voltage, and so on [8]. So an ideal and flawless compensator is needed to sidestep the outcomes of harmonics. Although numerous strategies and control techniques [9] have been evolved, still the performance of filters is under research.

For a growing number of operations, conventional tool proves to be inadequate for compensation of harmonic problem. Harmonics distortions have conventionally treated with employment of passive filters. However, the use of passive filter [10]-[11] may come out with parallel resonance in the system impedance, excess reparation of reactive power on fundamental frequency, along with reduced flexibility meant for dynamic reparation of diverse frequency components of harmonics. The growing severity of harmonics in electrical network has involved the interest of researchers to come up with dynamic and flexible solutions [12]-[14]. Such apparatus, usually recognized as active filter is capable to mitigate voltage and current harmonics. The benefit of active filter is, it automatically adapt to any variation in the electrical network or

the load. It can mitigate numerous harmonic orders; also not get affected via major changes within network characteristics, so as removing the possibility of resonance in between filter and the system impedance. Additionally, one more advantage is, they occupy extremely small space when compared to conventional passive filter.

As an effect APF acquire great awareness owing to exceptional harmonics repARATION in 1phase, 3phase with & w/o neutral electrical systems consisting of non-linear loads [15]. APF tools have been beneath the study and growth for imparting repARATION for harmonics, reactive-power. Voltage-harmonics doesn't considerably disturb the power-quality of the grid [16] provided size of PV-system is comparatively lesser. Current-harmonics is the utmost regular power-quality problem that is resolute by application of SAPF.

The performance of SAPF depends on control strategies applied [17]. Control of DC capacitor voltage, generation of reference current and generation of gate pulse are the main concern while operating SAPF. Several methods have been used and under research to control these factors of SAPF. Here in this paper focus is on the management of DC link up capacitor voltage using PI controller. Method used for reference current generation is the dq theory [18] and hysteresis current controller (HCC) is being used for controlling the gate pulse [19].

2. SAPF CONFIGURATION

For this configuration of circuit, a PWM based VSI is used, that operates in current control mode [20]. The current compensation is performed into time domain specification for quicker response. The objective is to establish compensating current on the parallel point such that the supply current becomes sinusoidal, since this SAPF is used for cancelling the current harmonics. Figure 1 represents the simplified drawing of SAPF.

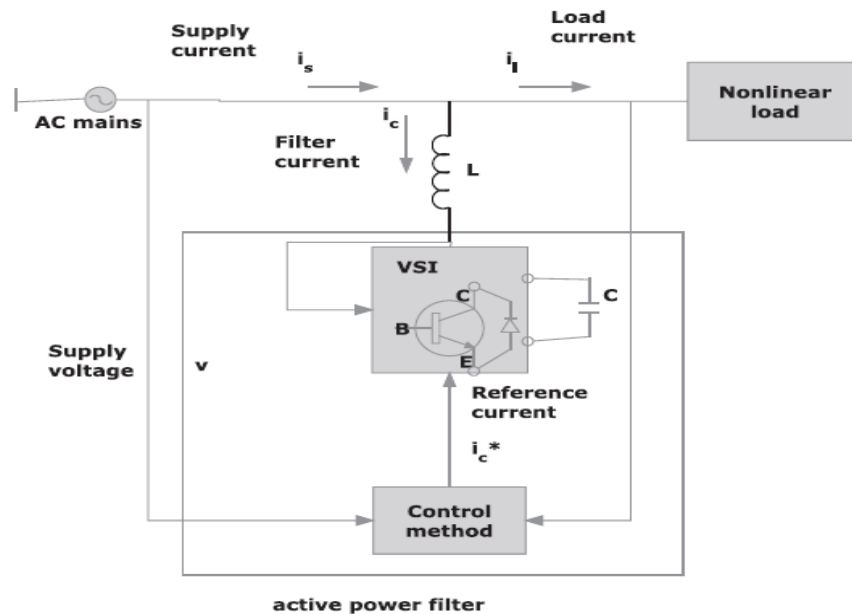


Figure 1. Simplified diagram of SAPF

3. DC LINK UP VOLTAGE REGULATION

At the instant when load fluctuates, equilibrium of active power between supply mains and load gets disturbed [21]-[23]. This active power distinction has to be balanced through DC capacitor. This moves the voltage of DC capacitor away from set reference voltage. This active power absorbed/delivered by the capacitor repays the power distinction between the power devoured by the load and the power provided from source [24]. If the voltage of capacitor is improved and reaches to reference voltage, active power provided by the supply source is believed to be same as absorbed by load again.

For controlling and maintaining voltage of DC link up capacitor, active power flow into SAPF requires regulation [25]. If the flow of active power in SAPF be maintained equivalent to losses inside it, the

voltage of DC link up capacitor can be preserved at required reference value. Consecutively, to uphold the DC linkup voltage constant and to produce the compensating recommended current, PI controller is developed.

3.1. Dc linkup voltage regulation with PI controller

Figure 2 demonstrates the internal configuration of PI controller. Comparison of actual voltage of capacitor with a fixed reference value is done, error signal so generated is then provided as input to the PI controller that contributes towards zero error in calculating the generation of reference current.

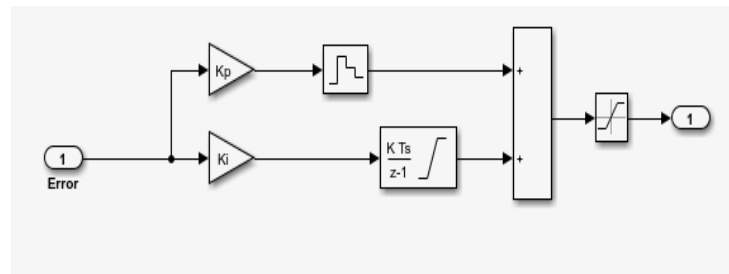


Figure 2. PI-controller design

4. SIMULATION RESULTS

The “performance evaluation” of SAPF is carried on using MATLAB 2018. Figure 3, represents the simulation model for PI based SAPF for harmonic mitigation of PV grid connected system. Figures 4 represents the THD of current at PCC with no SAPF, also distorted wave with harmonics is shown in Figure 5. Figure 6 represents THDi with SAPF. As seen from the figures, by connecting PI controller based SAPF, the THD-current has been reduced to 3.87% from 28.38%. Also from Figure 7 it's seen that harmonics are at minimum level providing the near about sinusoidal waveform of PCC current in comparison to distorted wave with harmonics.

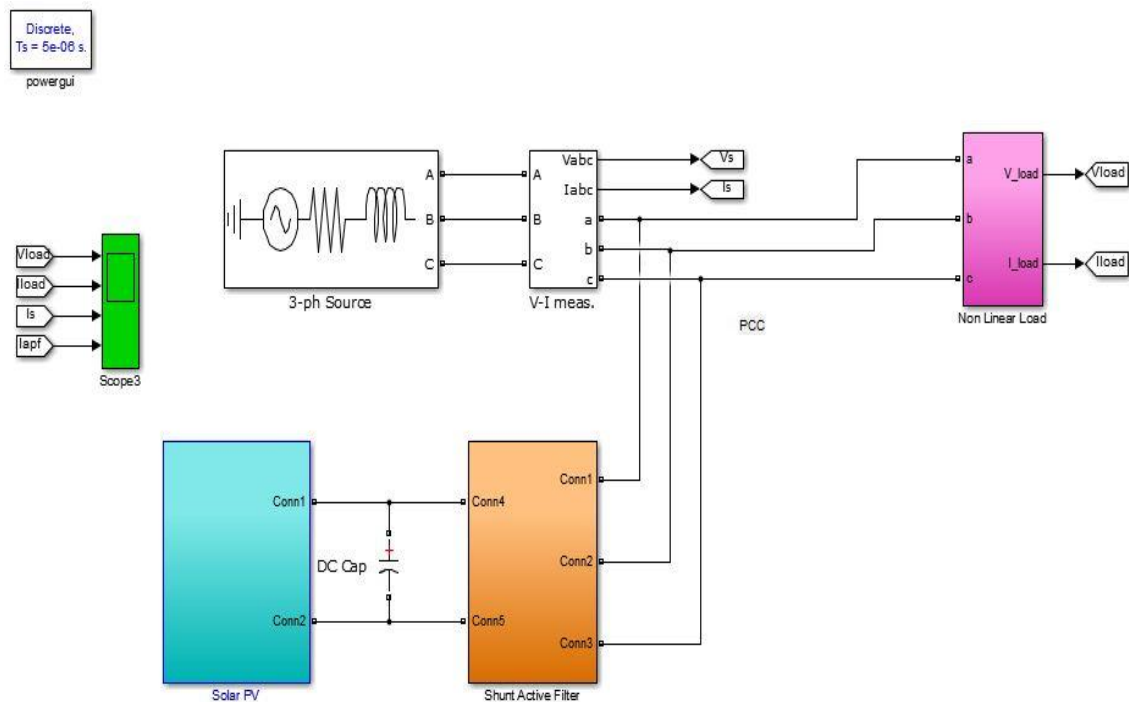


Figure 3. Simulink model of SAPF connected to PV-grid system

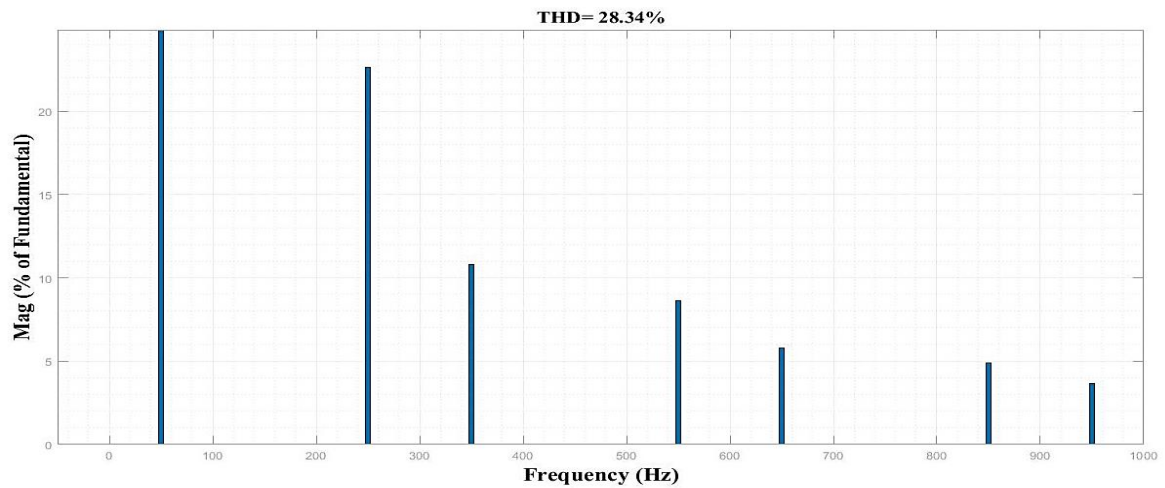


Figure 4. THD analysis of current at PCC

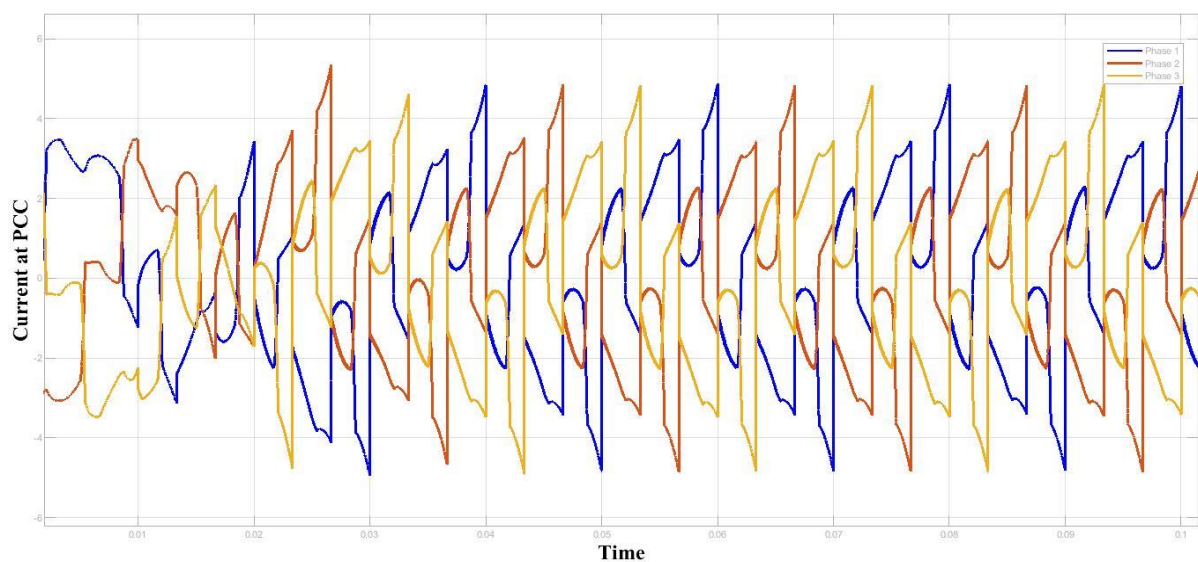


Figure 5. Current-waveform at PCC

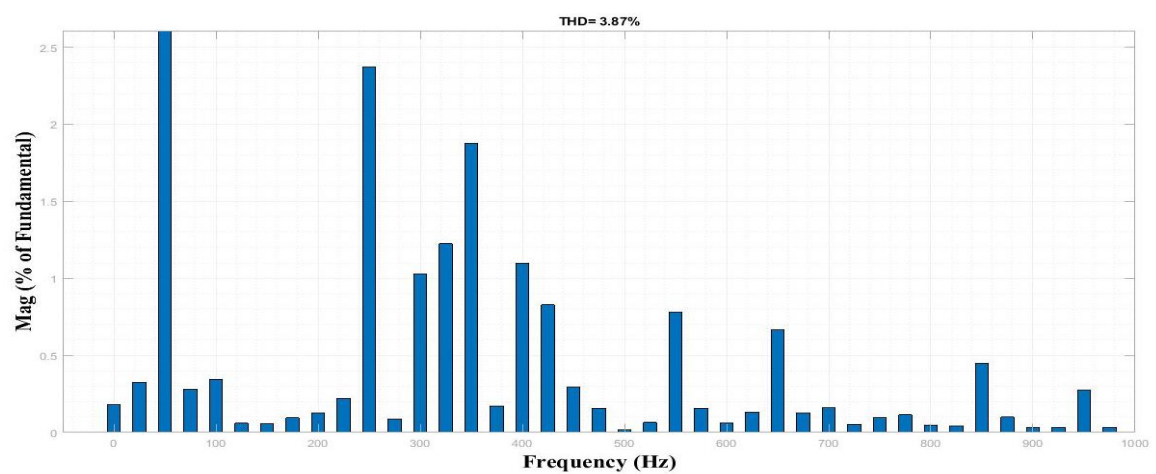


Figure 6. THDi at PCC with SAPF

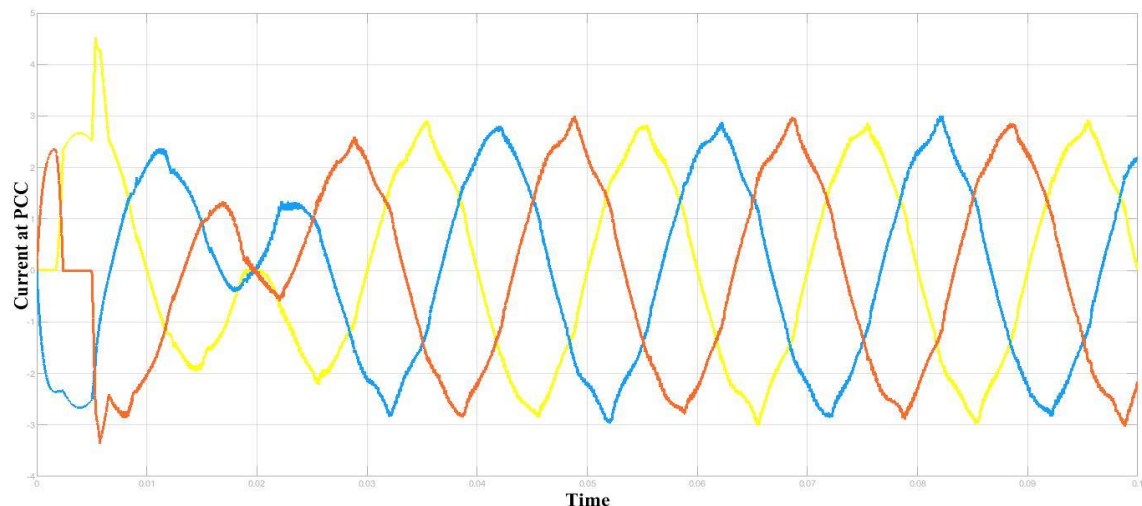


Figure 7. Current-waveform at PCC

5. CONCLUSION

The modelling and operation of SAPF is described illustrating performance assessment for compensation of harmonics. SAPF has been connected at PCC to compensate for current harmonics. To do so PI controller has been used to operate the SAPF effectively. The current harmonics has been reduced to a THD of 3.87%. It has been shown that by using SAPF next to PCC, the harmonics of PV grid connection can be maintained within the IEEE Std limit of 5%. The control method of PI based SAPF has reduced the harmonic distortion of current, also the dc linkup voltage of SAPF is nearly maintained constant to the fixed reference value in all circumstances.

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